# System Complexity and Stakeholder Needs: Ensuring river basin models for climate change adaptation are fit-for-purpose

## Report of Researcher Exchange May 2019

February 2020

INDIA-UK
Water Centre
भारत-यूके
जल केन्द्र

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www.iukwc.org

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The India-UK Water Centre promotes cooperation and collaboration between the complementary priorities of NERC-MoES water security research.

भारत-ब्रिटेन जल कें द्र एमओईएस-एनईसीआरसी(यूके ) जल सुरक्षा अनुसंधान के पूरक प्राथमिकताओ के बीच सहयोग और सहयोग को बढ़ावा देने के लिए करना है

*Front cover image: Waterfalls in Forest (Venkat Sudheer Reddy on Unsplash)*

# Contents

# Executive Summary

This report documents and discusses activities carried out under a Senior Researcher Exchange funded by the India-UK Water Centre (IUKWC) on the topic of "System complexity and stakeholder needs - ensuring river basin models for climate change adaptation are fit-for-purpose." This exchange enabled Prof. Ian Holman from Cranfield University, UK, to conduct a two week exchange hosted by Prof. Rajendra Singh at the Agricultural & Food Engineering Department of the Indian Institute of Technology Kharagpur, India, from 11th to 24th May 2019. This report provides background on the rationale for conducting the research exchange on the topic of the utility of river basin models for informing adaptation response to climate change, as well as a review of the objectives. This is followed by a description of the activities carried out under the exchange and a brief summary of themes and outcomes arising from an academic webinar and stakeholder-workshop conducted on the topics of systems modelling, user engagement and model evaluation. The report is intended for India-UK Water Centre members and stakeholders.

# 1. Activity Leads

## The Senior Researcher Exchange was convened by the India-UK Water Centre (IUKWC) and led by the Activity Leads:

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The Exchange was held at the Indian Institute of Technology Kharagpur, in Kharagpur, India, between the 11th and 24th of May 2019.

# 2. Aims

The India-UK Water Centre is based around five key cross-sectoral themes and aims to deliver a portfolio of activities across these themes. This activity focused on theme (5) that addresses transforming science into catchment management solutions, although it also addresses aspects of themes (1) Developing hydro-climate services; (2) Building cross-sectoral collaborations; and (3) Using new scientific knowledge to help stakeholders set objectives for freshwater management.

Addressing these in the context of future climate and socio-economic change requires models that (a) appropriately address and integrate current and future system complexity within the natural (soils, climate, vegetation, geology etc.); infrastructural (abstractions, reservoirs, water transfers etc.); water users (domestic, agricultural, ecosystems etc.) and governance (institutions, policies etc.) systems that control the movement, storage, use and return of water in a river basin; and (b) adequately represent adaptation to future impacts as a realistic process, subject to constraints, time lags, uptake limitations etc., to avoid over-optimistic assessments of the effectiveness of adaptation. This IUKWC Researcher Exchange addressed these two key points and particularly what is appropriate/adequate in the context of stakeholder needs and perceptions. The activity, thus, aimed to:

- Review approaches to the representation of system complexity and climate change adaptation within integrated models, systems models, and river basin models applied within IIT Kharapgur, Cranfield University and the UK-India Natural Environment Research Council/Ministry of Earth Science's Sustaining Water Resources programme;
- Discuss with local stakeholders, how the representation of these factors in models affects their trust in, and perceptions of, the reliability of model outputs;
- Provide MTech and PhD students with an improved understanding of the benefits, challenges and uncertainties in integrated modelling of the impacts of, and adaptation to, future climate and socio-economic change;
- Deliver written outputs on the challenge of balancing demands for increasing modelling complexity with stakeholder requirements of models, to provide trusted and useful model outputs to support climate change adaptation planning; and
- Forge stronger individual and institutional links to facilitate joint proposals to future Newton Fund, GIAN or GCRF calls.

# 3. Structure

The Exchange enabled a broad range of knowledge-sharing activities (Appendix 1) aimed at understanding and synthesising the comparative experiences of the visiting researcher and the host institution to consolidate learning, to identify existing challenges and gaps in knowledge, and to explore new research trajectories. This was achieved through one-on-one and group meetings, a webinar, and a stakeholder workshop.

Several in-depth meetings were conducted with Prof. Singh and water discipline colleagues within the Agriculture and Food Engineering Department (including Prof. Chandranath Chatterjee, Prof. Ashok Mishra, Dr Damodhara Rao Mailapalli and Dr Amey Pathak) and the School of Water Resources (Prof. Bhabagrahi Sahoo and Prof. Renji Remesan). In addition, presentations and discussions were arranged to understand the research works in Prof. Singh's Hydrology, Climate and Crop Modelling Group (HydroC2M), with PhD students Madhuri Dubey, Shashank Shekhar, Chwadaka Pohshna, Sonam Sandeep Dash, Mohite Archana Ramchandra, Subhankar Debnath

and Srishti Gaur; and Research Associate Dr Pranesh Paul, and with PhD students in the School of Water Resources (Dina Zaman, Daisy Koch, Swati Mishra, Soumi Dutta, Arnab Das, Aurobrata Das, Chittaranjan Dalai, Debi Prasad Sahoo, Mayank Suman, Ashutosh Pati, and Aiendrila Dey). The topics of discussions included, details of river basin modelling studies using a range of modelling approaches, climate change impacts and adaptation modelling, land-use and land cover change modelling, land surface modelling, water quality measurement, and agricultural field trials.

Two presentations were delivered to PhD and MTech students of the Agriculture and Food Engineering Department and School of Water Resources on “Integrated and systems modelling of global change” and “Successful paper writing skills”.

Several short meetings were held with senior management team members (Prof. Nirupama Mallick, Head, Rural Development Centre and Head, Agricultural and Food Engineering; Prof. Ashok Kumar Gupta, Head of the School of Water Resources; Prof. Swagata Dasgupta, Associate Dean, Continuing Education and National Coordinator of the Global Initiative on Academic Networks (GIAN); and Prof. Partha Pratim Chakraborty, Director of IIT Kharagpur) to discuss longer term strategic opportunities.

A visit was made to the Indian Institute of Engineering Science and Technology, Shibpur (IIEST) on 20th May to meet with Prof. Anirban Gupta (Head, Civil Engineering Department) and Prof. Kalyan Kumar Bhar, and discuss climate change research activities and potential future collaboration opportunities; and to give a presentation on Cranfield University and climate change impacts and adaptation. IIEST is a premier public university that is recognized as an Institute of National Importance under MHRD by the Government of India along with IITs and NITs.

A webinar was held at IIT Kharagpur (IIT-KGP) on 21st May on “Water resource systems modelling: balancing stakeholder needs, process representation and model complexity”. The webinar consisted of presentations by the three NERC-MoES SWR projects (SusHi-Wat, CHANCE and UPSCAPE) and by Prof. Ashok Mishra (IIT-KGP), followed by a discussion to bring out learning points for ensuring river basin models for climate change adaptation are fit-for-purpose. The webinar was promoted through the SWR projects and by the India-UK Water Centre. The webinar was attended by over 60 scientists from a wide range of universities, NITs and IITs across India, the UK and wider afield (including Vietnam). Participants came not only from organisations involved in the SWR Programme (such as ICRISAT, ATREE, IISc Bangalore, IIT Mumbai, IIT Roorkee, NIH Roorkee, University of Exeter, Heriot-Watt University etc.), but also through membership of the IUKWC (including NIT Karnataka, IIIT Hyderabad, NIT Jamshedpur, Amity University etc.).

The final main activity within the Exchange was a stakeholder workshop on “Exploring How to Ensure Hydrological Model Results are ‘Fit for Purpose’”. This one-day workshop was attended by about 45 delegates, including representatives from the Government of West Bengal (Irrigation & Waterways Department, Water Resources Development Directorate, West Bengal Accelerated Development of Minor Irrigation Project, and the Directorate of Agriculture (Soil Survey)) and the Central Water Commission (Teesta Basin Organisation, CWC, Kolkata). The workshop consisted of a mixture of presentations (from Profs Holman and Singh), individual exercises and discussion that explored stakeholder views with regard to interest in climate change impacts and adaptation, faith in models, importance of stakeholder engagement in modelling, model and modeller selection criteria, and model evaluation.


*Figure 1: Tweet about the 'Water resource systems modelling: balancing stakeholder needs, process representation and model complexity' webinar hosted on 21st May 2019*

*Figure 2: Stakeholder Workshop Participants at IIT Kharagpur*

# 4. Conclusions and Outputs

## 4.1. Key Themes

This IUKWC Senior Researcher Exchange enabled knowledge exchange and discussion of key issues of relevance to the development of more holistic tools and approaches to address the multi-faceted consequences of future climate and socio-economic change on water resources in India and elsewhere. Models that take a systemic perspective to integrate environmental, infrastructural, human, and governance systems, are potentially useful tools for supporting the understanding of the consequences of these future changes for the food-water-energy-environment nexus and for supporting communication across the science-policy interface. Key lessons that emerged from the activities of the exchange include:

- That there is no 'one size fits all' for systems-based modelling of water resources in India, but the successful projects explored in the Exchange had common characteristics:
  - The development of a system understanding through comprehensive data analysis and stakeholder engagement to inform system representation;
  - The selection of appropriate models or modelling approaches based on their suitability to match that system representation;
  - Approaches to simplification that were informed by system understanding and the purpose of the modelling; and
  - Stakeholder engagement to design the adaptations and interventions to ensure that model outputs matched stakeholder needs.
- The focus of much current climate change impact, adaptation and vulnerability (CCIAV) research in the Water-Energy-Environment-Food nexus has been on understanding the direct impacts of climate change on river flows, irrigation need, hydropower and reservoir performance etc, with less emphasis on the indirect or cross-sectoral impacts.
- Whilst climate change uncertainty is widely recognised and incorporated into CCIAV modelling study design, most have an implicit assumption of low future socio-economic uncertainty e.g. no change or Business as Usual (BAU). Given the importance that the stakeholders attending the workshop placed on socio-economic change, there are clear collaboration opportunities for UK expertise to help address knowledge gaps in socio-economic scenario development and quantification.
- Where adaptation responses have been simulated in river basin models, they have tended to focus on engineering responses, changes to infrastructural management or changes in crop practices or land-use/land cover change. There are significant opportunities to better represent changing multi-sectoral water demand, policy/governance and human dimensions (including knowledge, behavioural change etc.) that may strongly affect the effectiveness of many water and agricultural adaptations such that potential (unconstrained) adaptation is being represented.

## 4.2. Key Conclusions

This Senior Researcher Exchange has been an immensely rewarding experience that has strengthened the research capabilities of the two groups, and helped the activity leads to develop different perspectives and ideas for further research. The Exchange has demonstrated the state-of-the-art modelling being undertaken at IIT-KGP, and also the opportunities for further advancement and capacity building, as outlined above. The activities have increased awareness of the India-UK Water Centre and the NERC-MoES Sustaining Water Resource programme.

This Exchange also enabled preliminary exploration of pathways for continuing the collaboration between IIT-KGP and Cranfield University.

An accompanying IUKWC Brief summarizing the key thematic points arising from this Senior Researcher Exchange can be found at www.iukwc.org.

# 5. Annexes

## Annex A: Senior Researcher Exchange Schedule

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **Sat 11th May** | **Sun 12th** |
| | | | | | Depart London | Arriving at IIT Kharagpur |
| **Mon 13th** | **Tues 14th** | **Wed 15th** | **Thurs 16th** | **Fri 17th** | **Sat 18th** | **Sun 19th** |
| Introduction to Agricultural and Food Engineering Department and School of Water Resources and staff | Meeting with Head of Agricultural & Food Engineering Dept.<br>Meeting with Agricultural & Food Engineering and HydroC2M PhD students | Meeting with Head of School of Water Resources<br>Meeting with BTech, MTech and PhD students from School of Water Resources<br>Lecture by Prof Holman to MTech and PhD students on integrated modelling of the impacts climate and socio-economic change | Meeting with staff in School of Water Resources<br>Lecture to MTech and PhD students on improving academic paper writing skills<br>Meeting with Director of IIT Kharagpur | Meeting with staff in School of Water Resources | | |
| **Mon 20th** | **Tues 21st** | **Wed 22nd** | **Thurs 23rd** | **Fri 24th** | | |
| Visit to Institute of Engineering Science and Technology, Shibpur, including meeting with Head of Department and selected faculty members and guest lecture to MTech and PhD students on climate change impacts and adaptation | Meetings on development of a National Hydrological Model on India and on IMPRINT project<br>Webinar on systems modelling with IIT-KGP, IUKWC and SWR programme members | One-day stakeholder workshop on ensuring modelling studies are fit for purpose | Wrap-up activities<br>Transfer to Kolkata | Return to London | | |

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